Quantifying the Performance of Rooftop Farms in the District's MS4

UDC Green Roof

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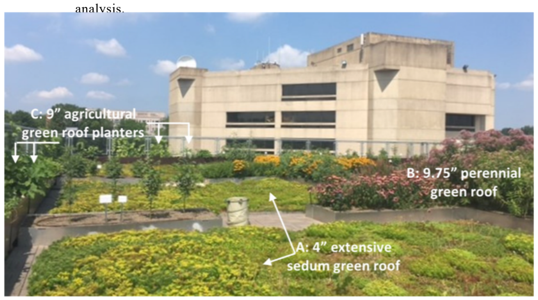
Projects Description

In January 2013, Mayor Gray signed the Sustainable DC Act into law which is a comprehensive approach to creating sustainability across sectors. The ultimate goal is to make 100 percent of the city's waterways fishable, swimmable and to improve residents' food security. One approach to creating sustainability is through the use of green infrastructure technologies such as green roofs. Since 2012, The District has added more than 1.5 million SF of green roof space and improved food access. One example is UDC's Green Roof, built-in 2015, the intended goal is to educate students and the communities on sustainable agriculture practices in urban areas. However, few green roof studies have considered the potential combined benefits of crop production and stormwater control, creating challenges for DOEE policy and initiatives. In this project, we aim to address substantial gaps in knowledge that link agricultural and extensive green roof design variables and system management to efficacy as a stormwater control technology.

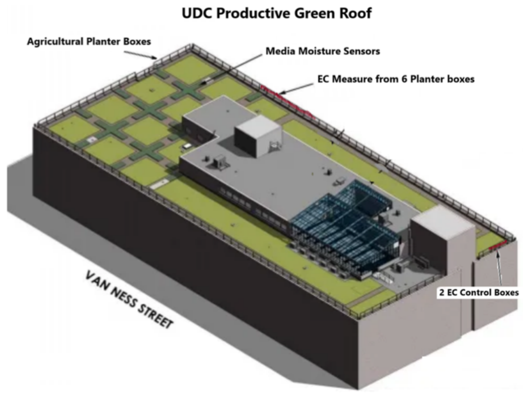
Objectives

1. Thoroughly characterize the discharge from extensive stormwater green roofs, agricultural (crop-producing) green roofs for nitrogen, phosphorus, and suspended solids over a wide range of storm events.
2. Field test multiple materials installed as a mixed-in amendment or a downstream permeable reactive barrier treatment to reduce off-site discharge of nutrients from extensive green roofs and agricultural green roofs.
3. Identify the materials and conditions that influence the level of nutrients in green roof discharge.
4. Quantify the impacts of agricultural green roof substrate depth, composition and water retention characteristics, and irrigation on event-based and cumulative stormwater retention.
5. Derive operation and management strategies for extensive and agricultural green roofs based on statistically robust, comprehensive data analysis.



Need for study

Green Roofs are an important Green Infrastructure (GI) technology designed to reduce the demand of urban drainage system. (Fassman-Beck et al., 2013; Nawaz et al., 2015; Wadzuk et al., 2013). However, studies are showing green roofs may substantially elevate the concentrations of priority stormwater pollutants, nitrogen and phosphorus, compared to ground level runoff, i.e., solving one problem may create another (Barr et al., 2017; Berndtsson, 2010; Fassman-Beck and Simcock 2013; Teemusk et al., 2011). Elevated nutrients in green roof discharge could contribute to eutrophication in downstream aquatic environments.



System To Be Evaluated

College of Agriculture, Urban Sustainability and Environmental Sciences (CAUSES) at UDC has a combined 20,000 ft^2 agricultural and extensive green roof on Building 44 at the Van Ness campus, which enables comparative evaluation of water quality, the extent to which green roofs of different depths retain stormwater, and evapotranspiration (ET). The facility is comprised of: 4"-depth extensive sedum roof; 9.75"-depth perennial green roof areas; 9"-depth agricultural green roof planters growing strawberries, peppers, tomatoes, hibiscus, and sweet potatoes (Figure 2). Depth of each green roof configuration was field-verified 06/21/2019.

A tipping bucket rain gauge on the UDC green roof measures rainfall at intervals of 0.01mL. Time Domain Reflectometers (TDRs) are used to measure soil moisture in the UDC green roof. Sensors in the 9.75" perennial green roofs are installed at two depths (upper = 2''and lower = 6''). Sensor technology itself limits measurement a single mid-depth installation in the 4" extensive configuration. Moisture profile development during wet weather will be used to assess how deep rainfall infiltrates into the substrate, and thus whether deeper green roofs do actually control more stormwater. Dry weather data is used to determine daily evapotranspiration (ET), calculated as the moisture loss over successive 24-hr periods.

Continuous electrical conductivity (EC) monitoring provides a cost-effective, semi-quantitative method to compare mineral levels in discharges from the agricultural planters and from the UDC green roof as a whole. EC measures total salts, which includes all soluble in an agglomerated metric. The benefit of using EC probes, as opposed to capturing samples for specific nutrient analysis, is that water quality can be compared from all storm events as well as irrigation runoff in a resource-efficient manner.

References

Fassman-Beck, E., & Simcock, R. (2013). Hydrology and Water Quality of Living Roofs in Auckland. *NOVATECH 2013*.

Nawaz, R., McDonald, A., & Postoyko, S. (2015). Hydrological performance of a full-scale extensive green roof located in a temperate climate. *Ecological Engineering*, *82*, 66-80.

Wadzuk, B. M., Schneider, D., Feller, M., & Traver, R. G. (2013). Evapotranspiration from a green-roof storm-water control measure. *Journal of Irrigation and Drainage Engineering*, *139*(12), 995-1003

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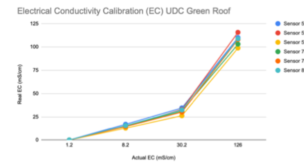
Sampling / Electrical Conductivity Measurement Collection

Discharge from 8 existing agricultural green roof planters containing three crops (strawberries, tomatoes, salad greens) and 2 perennial plants. The water discharge is channeled through a PVC pipe and into collection bins for EC measurement and sample collection after each rain event. Additionally, the total volume is recorded and 100 ml runoff sample is taken from each planter box to test for nitrogen and phosphorus for each rain event. The electrical conductivity measurement was taken by placing Hydros CD-10 conductivity in each planter box.



Design Capacity:

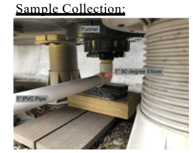
Planter Box Dimension: 24"L x 72"W x 18"H
Volume of 1" Rain: 24"L x 72"W x 1"H = 1728 in^3 => 7.481 Gallons.

Bin Dimension: 25.75"L x 18.75"W x 7.125"
- Height of the hole: 3"

Volume of Water: 25.75"L x 18.75"W x 3" = 709.83 in^3 => 6.27 Gallons

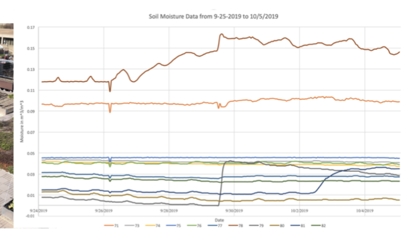
Hydros CD-10 sensor was placed vertically in each corner of the bins. The bins were placed on an inclined block to funnel the water to corner to measure the electrical conductivity of minor rain events.

Sample Collection:



Runoff was captured from each planter box through a funnel system that directed the runoff from the planter boxes to each bin. A removable nozzle was inserted to freely disccncne the system to remove the water after each rain event.

Soil Moisture Collection



Time Domain Reflectometers were installed in Oct. 2018 and collect data on 1-hour intervals. As described in section 2.3, the sensors were placed at different depth of 2" and 6" in the deeper beds and depth of 2" in the sedum extensive green roof. Soil moisture measurement was done using the CS655, a multiparameter smart sensor. Additionally, the soil moisture content of each planter box was taking using EC-5 soil moisture sensors.